A-298

GEORGIA INSTITUTE OF TECHNOLOGY

ENGINEERING EXPERIMENT STATION

ATLANTA, GEORGIA

12 November 1956

University of Michigan
Engineering Research Institute
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. Weston E. Vivian

Reference: Subcontract under Michigan Prime Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 1, October 1956

Gentlemen:

A summary of progress for the period 1 October through 31 October 1956 on the referenced contract is contained herein.

Prosecution of the contract has been designated Engineering Experiment Station Project A-298. The project is under the general supervision of M. W. Long, Head, Radar Development Branch of the Physical Sciences Division, and under the direct supervision of J. S. Hollis, Project Director.

A study of the overall radiometer problem is in progress; a review of the classified and unclassified literature is being made, and reports on recent developments which are not in the Engineering Experiment Station files have been requested. Specific programs of investigation are directed toward consideration of the Foster scanner, the three-dimensional and geodesic Luneberg lenses and electrically-actuated ferrite phase shifters as solutions of the radiometer scanning problem. Analysis of the toroidal reflector with organ pipe feed, mechanical and gas-tube phase shifters, and other scanning devices will be undertaken when personnel complete the above assignments. Preliminary experimental measurements are being made at X-band in the development of a broad-band rotary joint which would be required for use with an organ pipe feed system for the geodesic lens or the toroidal reflector. Results of X-band measurements in the development of a broad-band waveguide ring switch on a concurrent

Engineering Experiment Station contract (DA-36-039 SC-72789) indicate that it may be possible to develop a switch of this type for use in a radiometer system.

A trip was made by J. S. Hollis to General Electric in Schenectady, New York, for conferences with G. E. Feiker and C. C. Allen concerning problems associated with the use of the organ pipe for feeding the geodesic Luneberg lens.

Research personnel who have been assigned to the project on a full time or part time basis are listed below.

	Percent of Full Time
J. C. Butterworth, Research Assistant	100
A. L. Holliman, Research Engineer	70
J. S. Hollis, Special Research Engineer	40
M. W. Long, Special Research Engineer	10
C. R. Lord, Research Assistant	100
R. C. Johnson, Assistant Research Physicist	25
W. K. Pursley, Research Associate	15
A. H. Schaufelberger, Research Physicist	50
John Taylor, Research Professor	20

The program of investigation for the month of November includes continuation of the theoretical and experimental work which is now in progress and investigation of the toroidal reflector with an organ pipe feed.

Yours very truly,

J. S. Hollis
Project Director

Approved:

M. W. Long, Head
Radar Development Branch

JSH:mb

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GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

A-298

11 December 1956

University of Michigan
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. James W. Lester, Jr.

Reference: Subcontract under Michigan Prime Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 2, November 1956

Gentlemen:

A summary of progress for the period 1 November through 30 November 1956 on the referenced contract is contained herein.

The program of theoretical and experimental investigation is continuing which is directed toward a comparison of antenna configurations for meeting the contract-specified minimum requirements or goals.

The following scanning configurations have been under investigation and the indicated tentative conclusions have been reached. Potentialities of these and other scanners will be discussed in more detail in the quarterly report.

1. Foster Scanner. The Foster scanner is a theoretically aberration-free device for scanning over a sector. However, operation is impaired over wide frequency ranges because of the frequency sensitivity of choke joints which are required for coupling between the rotor and external waveguide media.
2. Three-Dimensional Luneberg Lens. The three-dimensional Luneberg lens is theoretically aberration-free and is capable of providing a means for scanning over 4π steradians by movement of the feed. Although research on this type of lens is in progress by several activities, no satisfactory lens appears to have been developed to date for use in the 30 to 40 kmc band.

3. Geodesic Luneberg Lens. The geodesic Luneberg lens is also theoretically aberration-free, and in conjunction with a cylindrical reflector provides a means for scanning a pencil beam over a 60-degree sector. The bandwidth of this scanner is limited by the bandwidth of the feed mechanism.

   a. Organ Pipe Feed. The organ pipe feed has the advantage of having a small rotating feed horn, however it is critical and tedious to manufacture in that all waveguides connecting the feed circle of organ pipe with the feed arc of the Luneberg lens have to be adjusted to the same length within extremely close tolerances. Use over a broad band also requires development of a rotary joint which is operable over the band.

   b. Ring Switch. The geodesic lens using a ring switch feed appears to be capable of meeting the minimum system requirements completely and in meeting the specified goals except with respect to polarization and overall size requirements.

4. Toroidal Reflector. The toroidal reflector and feed constitute a scanning device which is capable of scanning a 120-degree sector, however it has inherent phase errors which are independent of the sector scanned. These errors limit its use to applications requiring resolution of not less than 3 or 4 degrees.

5. Arrays with Ferrite Phase Shifters. On the basis of preliminary literature searches and conferences with research personnel of the Naval Research Laboratory it appears that the present state of the art of ferrite development and application does not permit scanning over the required scan sector with a beam having a width of 0.015 radian. In addition there are serious problems associated with attaining extremely broad system bandwidths. Further study is in progress.

During this report period one trip was made; J. S. Hollis and C. R. Lord visited Naval Research Laboratory for conferences with A. J. Simmons, H. N. Chait and N. G. Sakiotis in connection with the application of ferrites to the solution of the radiometer scanning problem.

The program of investigation for the month of December includes continuation of the theoretical and experimental work which is now in progress, attendance at the Georgia Tech-SCEL Symposium on Scanning Antennas, and preparation of a quarterly report.

Yours very truly,

J. S. Hollis
Project Director

Approved:

M. W. Long, Head
Radar Development Branch

JSH:mb

A-298

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

14 January 1957

University of Michigan
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. James W. Lester, Jr.

Reference: Subcontract under Michigan Prime Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 3, December 1956

Gentlemen:

A summary of progress for the period 1 December through 31 December on the referenced subcontract is contained herein.

Investigations for determining a solution to the specified scanning antenna problem have continued, with emphasis on the geodesic Luneberg lens with ring-switch feed, Foster scanner, multiple dish scanner with ring-switch feed, and ferrite scanning techniques. In addition, trough waveguide scanners and multiple-channel, passive frequency scanning techniques are being examined.

The problem of determining the allowable variation in the reflection coefficients of individual components of a scanning system with frequency and beam orientation is being analyzed and preliminary results are encouraging.

Research personnel associated with the project attended the Georgia Tech-SCEL Symposium on Scanning Antennas which was held on the Georgia Tech campus. It is felt that attending the symposium afforded worthwhile information on the state of the art of scanning techniques.

The program for the month of January includes extension of the theoretical investigations which are in progress and continuation of

experimental measurements, which are for the purpose of determining the broad-band capabilities of the geodesic Luneberg lens and an associated ring-switch scanning mechanism.

Very truly yours,

J. S. Hollis
Project Director

Approved:

M. W. Long, Head
Radar Development Branch

A-298

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

14 February 1957

University of Michigan
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. James W. Lester, Jr.

Reference: University of Michigan Purchase Order 190812
Signal Corps Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 4, January 1957

Gentlemen:

A summary of progress for the period 1 January through 31 January is contained herein.

Investigations during this report period have been concentrated on problems associated with the development of a geodesic Luneberg lens scanner with a ring switch feed, determination of allowable ferrite losses in a scanning array, evaluation of the contractual technical specifications, and preparation of a quarterly progress report.

The study to determine the allowable reflection coefficients over the band for a geodesic Luneberg lens scanner with ring switch feed has continued. Under the assumption that there are four reflection coefficients of equal magnitude which vary across the 30 kmc to 40 kmc frequency band in accordance with relation

$$\Gamma = \Gamma_{max} \left[1 - \sin \pi \left(\frac{f - 30 \text{ kmc}}{10 \text{ kmc}} \right) \right] ,$$

and with the path lengths between reflection coefficients varying in a realistic manner with scan, it was found that Γ_{max} can be as high as 0.25 without causing a variation in reflective attenuation with scan of more than 0.1 db.

Calculations indicate that an array employing 120 series ferrite elements with a cosine illumination taper has an overall attenuation of 1.5 db for an attenuation per element of 0.05 db. This is in agreement with results obtained by A. J. Simmons of Naval Research Laboratory.

The program for the month of February includes continuation of the theoretical and experimental investigations which are in progress and initiation of study of the radome problem.

Very truly yours,

J. S. Hollis
Project Director

JSH:mb

Approved:

M. W. Long, Head
Radar Development Branch

A-298

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

14 March 1957

University of Michigan
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. Harold E. Sturm

Reference: University of Michigan Purchase Order 190812
Signal Corps Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 5, February 1957

Gentlemen:

A summary of progress for the period 1 February through 28 February 1957 is contained herein.

Calculations have been made to determine the reflective attenuation for concurrent reception of a 3/4-wavelength "A" sandwich radome with 0.030-inch fiberglas laminate skins having an effective dielectric constant of 3.5 for radiation polarized normal to the plane of incidence. The attenuation was found to be 1.3 db at the center of a ± 30-degree scan sector and 2.0 db at the edges of the sector. Similar calculations for a 3/4-wavelength sandwich with 0.030-inch high-impact-styron skins with a dielectric constant of 2.66 indicate a reflective attenuation of less than 0.5 db over the above scan sector. Transmission and structural tests are planned for a 3/4-wavelength sample panel using this material over a polyfoam core. Studies of the design of broadband radomes are continuing.

Studies are in progress to determine desirable configurations for a scanner employing a geodesic Luneberg lens with a ring-switch feed and a parabolic cylinder reflector which are suitable for mounting in a C-46 aircraft.

Measurements are being made to determine a primary feed horn configuration for feeding a geodesic lens which will provide the required side lobe suppression for concurrent reception over the 30-40 kmc frequency range.

J. S. Hollis visited Bell Telephone Laboratories at Whippany, New Jersey, for conferences with Dr. Wilhelm Von Aulock concerning the application of ferrites to the solution of the radiometer problem. Dr. Von Aulock indicated that problems which would be encountered are: (1) lack of knowledge of the characteristics of ferrites at K_a band, (2) the stringent requirements on uniformity and loss, and (3) the inherent frequency dispersion of the tensor permeability in ferrites.

The program for March includes conclusion of the above theoretical and experimental investigations and initiation of work on a final report.

Very truly yours,

J. S. Hollis
Project Director

JSH:mb

Approved:

M. W. Long, Head
Radar Development Branch

A-298

GEORGIA INSTITUTE OF TECHNOLOGY

ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

12 April 1957

University of Michigan
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. Harold E. Sturm

Reference: University of Michigan Purchase Order 190812
Signal Corps Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 6, March 1957

Gentlemen:

A summary of progress for the period 1 March through 31 March 1957 on the referenced purchase order is contained herein.

The major part of the effort during this report period has been devoted to preparation of the final report. Rough drafts of about half of the report sections have been completed. In addition, work is continuing on measurement of the losses of a sample radome panel and in determination of a desirable feed configuration for a geodesic Luneberg lens scanner.

The program for April includes conclusion of the above investigations and continuation of work on the final report.

Very truly yours,

J. S. Hollis
Project Director

JSH:mb

Approved:

M. W. Long, Head
Radar Development Branch

A-29

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

14 May 1957

University of Michigan
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. Harold E. Sturm

Reference: University of Michigan Purchase Order 190812
Signal Corps Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 7, April 1957

Gentlemen:

A summary of progress for the period 1 April through 31 April 1957 on the referenced contract is contained herein.

Work is continuing on preparation of the final report. Rough drafts of most of the sections have been written and drawings for figures are being prepared. Investigations to determine a final feed configuration for a geodesic Luneberg lens scanner have been completed.

The program for May includes continuation of the work on the final report and completion of the radome panel measurements.

Very truly yours,

J. S. Hollis
Project Director

JSH:mb

Approved:

M. W. Long, Head
Radar Development Branch

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

14 June 1957

University of Michigan
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. Harold E. Sturm

Reference: University of Michigan Purchase Order 190812
Signal Corps Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 8, May 1957

Gentlemen:

A summary of progress for the period 1 May through 31 May 1957 on the referenced contract is contained herein.

Work is proceeding on preparation of the final report. Final rough drafts of all sections have been written, drawings for figures have been completed and final editing is in process. It is anticipated that delivery of the report will be made on or before 1 July 1957.

Very truly yours,

J. S. Hollis
Project Director

JSH:mb

Approved:

M. W. Long, Head
Radar Development Branch

LIBRARY DOES NOT HAVE PROGRESS LETTER # 9

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

15 July 1957

University of Michigan
Willow Run Laboratories
Willow Run Airport
Ypsilanti, Michigan

Attention: Mr. Harold E. Sturm

Reference: University of Michigan Purchase Order 190812
Signal Corps Contract DA-36-039 SC-52654

Title: An Experimental Microwave Antenna

Subject: Progress Letter No. 10, June 1957

Gentlemen:

A summary of progress for the last month, June 1957, on the referenced contract is contained herein.

Most of the effort during June was devoted to preparation of the Final Report: A Survey of Microwave Scanners for a Radiometer, by R. M. Goodman, Jr., J. S. Hollis and R. C. Johnson. This report was shipped 5 July 1957 to the University of Michigan, Attention: Mr. Harold E. Sturm.

Personnel of the Engineering Experiment Station wish to express appreciation for the splendid cooperation furnished by the technical and administrative personnel of the Willow Run Laboratories. The work of Mr. Weston E. Vivian was especially significant to the success of this project.

Very truly yours,

for J. S. Hollis
Project Director

Approved:

M. W. Long, Head
Radar Development Branch